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PROCEEDINGS

MR. BONNEY: Very simply, ladies and gentlemen, what this is going to be is a press session on the mechanics of space flight. We are not going to talk about specific projects, but we are going to try to present some of the basic, fundamentals and we will have two of our scientists giving that presentation in about a half-hour period.

Then we will open the thing up for questions and answers. None of the speakers anticipate talking about any past, present or anticipated space programs. We expect no hard news out of this, but everything that will be said will be on the record and may be for attribution.

The speakers are Newell Sanders, Homer Newell and Jack Clark. I will give you the full names. It is Homer E. Newell, Jr. Homer is Assistant Director for Space Science. It is Newell D. Sanders. He is Assistant Director for Advanced Technology. The third gentleman is John F. Clark, who is Chief of our Ionosphere Program. John will not be making a formal presentation, as I understand it, but will be participating in the question and answer period.

One other thing: If the whole operation gets too technical or you get lost, throw in a question from the floor as we go along, but let's try to keep those brief. Let's try to keep most of the questions for the question and answer period that will follow the formal presentation. These gentlemen are all from NASA.

QUESTION: Will there be a transcript?

MR. BONNEY: We expect it will be a couple or three days before we have copies of it. This is so these gentlemen can clean up their remarks a little bit and pull some of the "oohs" and "aahs" out of it.

QUESTION: Do you have any more envelopes with the handouts?

MR. BONNEY: They have nothing to do with today's presentation. We will give you those at the end of the session.

Homer Newell will be the first speaker. Mr. Newell.

MR. NEWELL: Thanks, Walt.

Ever since 1945, as you are well aware, the United States has been using rockets for studying the earth's atmosphere. These rockets we call sounding rockets, and for the purposes of now and in the future, I would like to propose a definition of sounding rocket.

Let us say that by sounding rocket we mean a vehicle that goes out to one earth's radius, or up to that distance. Thus, when we talk about space probes, then, we will mean vehicles that go out beyond the distance of one earth's radius from the surface of the earth.

With the sounding rockets over the past 12 years we have been able to investigate the atmosphere of the earth and to study its pressure, temperature, density, which are important in the design of vehicles that go through the atmosphere, either launching vehicles for satellites or high altitude aircraft, and so on.

We have been able to measure the winds in the atmosphere and to study its composition, both the neutral molecules and atoms and the ions. We have been able to measure the magnetic field of the earth and to observe those variations in magnetic field that are associated with radio blackouts and, hence, are important to understand in connection with communications.

We have been able to measure the ionosphere, which is the region of our atmosphere that is electrified, and, of course, again is important for radio communications.

We have been able to study the aurora, the northern and southern lights, and other radiations from the upper atmosphere and make measurements of cosmic rays.

All of these things that I have mentioned are associated with the atmosphere itself. In addition to studying the earth's atmosphere, we have been able to peek out into the space about us to study the sun by means of its radiation and to, in fact, study the stars not only in the radiations that we see at the ground, but in terms of ultraviolet light and X-rays that come to us from the stars.

With advancing technology we can go beyond the studies that have been possible with sounding rockets. We are able to send up satellites that can go in orbits near the earth or in space probes that go out on long trajectories at great distances from the earth.

The details of the mechanics of creating these satellites and getting these space probes out into space is what Newell Sanders will talk to you about a little later.

The question that I would like to discuss is what are we interested in measuring and observing by means of the satellites and deep space probes?

To begin with, the scientist, in his usual logical fashion, would like to ask himself by means of his instrumentation the question of where does our atmosphere really end, and when it comes to an end, what does it wind up as? Does it, for example, wind up as simply the medium of interplanetary space, just a few particles per each cubic centimeter, or does it, as many people think, wind up as part of the sun's atmosphere?

You have all seen pictures of the sun's corona as it appears during a solar eclipse, this great halo around the sun. This actually is part of the atmosphere of the sun.

Now, the question is does that atmosphere really extend all the way out to the distance of the earth, and are we enveloped in a cloud of particles that belong to that solar atmosphere?

The second question that the physicist would like to ask is how far does our ionosphere extend? We have indications from rocket soundings and from ground-based measurements that there is a considerable amount of charged matter between us and the moon. We would like to learn the details of that.

Thirdly, we would like to know how the earth's magnetic field continues to fall off. Does it fall off as one would imagine in a more or less steady way, or is it modified by the material in space by the electrified particles in space, and so on?

Fourth, we would like to continue our study of the high-energy particle radiations like the cosmic rays and this is, as you know, continued in the satellites and space probes that have been launched to date.

The Van Allen radiation belt is a discovery in this area although these particles are not cosmic rays since they are not that energetic; nevertheless, they are of a similar nature. We would like to know whether this radiation belt continues all the way out to the moon or does it reach a maximum and then trail off?

Then, of course, if you look to the future and ask yourself the question of what future manned spacecraft we will run into, this radiation question is of extreme importance.

Going further, looking toward the future, we would like to ask several questions about the moon and planets. If we get our space probes to take our equipment to the vicinity of the moon, then we have a number of questions.

Does the moon really have an atmosphere? We know that it can't be much of an atmosphere, because we would see a halo around the moon if there were much of a one. If it has an atmosphere, say, of heavy gases, say Argon, Xenon and Crypton, is that ionosphere?

Does the moon have a magnetic field? What is the moon's gravitational field like? By studying the moon's gravitational field, one can get a measure of its precise shape.

As you all know, the moon is not a perfect sphere nor is it a simple sphere with a bulge around it the way the earth is. The moon is more like a lopsided football with three different axes to it.

We would also, in the more distant future, like to ask similar questions about, say, Venus and about Mars. What is the atmosphere of Venus really like? When we observe

Venus at the surface of the earth by means of ordinary astronomical techniques, we see great clouds of carbon dioxide, but we don't see any water vapor. Our first question is, is it true that Venus has no water? I do not believe this is true. I believe when we look into the atmosphere we see only a portion of the atmosphere where there is carbon dioxide, but if we could look further into it we would find water vapor.

The question is, is this true? What is the total atmosphere of Venus like? Does it have an ionosphere? Does Venus have a magnetic field and are there entrapped particles around Venus like those of the Van Allen belt around the earth?

Then turning out to Mars, does Mars have in its atmosphere any appreciable amount of water vapor? We suspect not. Does Mars have an ionosphere? When we get close to these objects, of course, we would like to take pictures of them to study them directly by photography, by television or any other means.

This is a very brief review of the things we would like to learn. They represent a step forward, a logical series of steps forward from things that we have been measuring in our own earth's atmosphere.

As we attempt to make these measurements and studies, we are sure that other questions will arise and other challenges, and we will want to pursue those.

Now, at this point I would like to turn the floor over to Newell Sanders, who will tell you something about the mechanics of getting these instrumentations out into the space that we would like to study.

QUESTION: You say by studying the gravitational field of the moon you might be able to find out what?

MR. NEWELL: We can find out more about the mass, size and shape of the moon, because the mass, the size and the shape of the moon determines the nature of its gravitational field, so conversely, by studying the nature of the gravitational field we can learn about its shape.

QUESTION: What is the size of that bulge that is to be determined now?

MR. NEWELL: On the moon, I can't give it to you offhand, but it is quite marked. It is more marked than the bulge of the earth.

MR. SANDERS: The first thing I would like to discuss with you is how we get out into space, what kind of path do these objects that we push out there follow?

For most of the flight, practically the entire lifetime of these vehicles, they are just flying through space, just drifting through space, as it were, for a period of perhaps five minutes near the beginning in which they get this violent acceleration from the rocket that pushes it up, but once this acceleration has died out and the rocket is dropped and the vehicle proceeds through space. It is flying on a trajectory in the same way that the moon and the other objects in our solar system are moving, following the same laws that the astronomers have worked out.

Now, let's take a look at a few of the kinds of paths that will be followed and I will start with the one that you are quite familiar with, the orbit around the earth, just as a starting point, and you are familiar with some of these concepts already, which is where we have essentially a circular orbit around the earth.

This is the earth. The vehicle is moving with the velocity such that it rotates around the earth. The centrifugal force which is generated just balances the gravitational force of the earth, and as a consequence, it will follow this path and not fall into the earth.

Starting from that point, we would like to reach out into space; we would like to go out to the moon, to Venus and to other parts of our solar system, and the question is how do we modify this system, this orbit, to get the kind of path that we want, having restored it?

Let's assume this vehicle has on it a rocket, and as it comes to this point we fired this rocket and gave it a velocity which is greater than the velocity that it would have just for this circular orbit. When we do that, due to the greater velocity, it will not curve quite as much. It will fly farther away from the earth and follow an elliptical path, something like this. But all of these paths will always come back and pass through this same point.

If we apply still a greater velocity, we will get something like this. Let's look at what these velocities are. For the circular orbit, this velocity has to be 18,000 miles per hour, roughly.

QUESTION: Are these statute miles?

MR. SANDERS: Yes, approximately. I know these numbers quite well in per-second, but I can't quite convert them in miles per hour.

If we continue to increase this velocity by use of increasing rocket charges, we will get a family of ellipses which extend farther and farther into space. In general, as these vehicles move around these orbits, as they move away from the earth, they will slow down and will be going at a slow velocity at these points and they start falling back to the earth and, again, are going at the velocity in excess of 18,000 miles per hour at this point.

If we keep on pushing that velocity up, until we get to 25,000 miles per hour, a strange thing happens. This ellipse never closes itself. These arms extend on out into infinite, and the vehicle will in a sense escape and keep on going and, in a sense, never come back.

There is a misconception here that I think it would be well to clear up. The vehicle has not escaped the gravitational field of the earth in the sense that the gravitational field of the earth has disappeared. The field of the earth extends to infinite, and it is permanent and it will always extend to infinite, so this vehicle will be in the gravitational field of the earth forever.

However, the point is, the gravitational field does decrease with distance. It is the inverse square of the distance. As the vehicle goes away, it is slowing down. When you lift something to higher altitudes, it loses velocity. It is not losing velocity at a fast enough rate. It cannot rob the total energy from the vehicle. This energy remains and continues and pushes the vehicle out into space, but it still feels the effect of gravity, but it will never return to the earth.

Now, then, let's suppose instead of going out far into space we think about going to some intermediate objective, such as the moon. We would like to extend these ellipses until the ellipse comes out far enough so that is reaches the moon orbit and to do that we need the velocity of 23,900 miles per hour. This brings up an interesting point. Actually, going to the moon, the step between going to the moon and escaping entirely is not a very big step.

As a matter of fact, if we miscalculate the size of our charge in our rocket system, or do something incorrect in our guidance, it is quite possible in shooting at the moon that whereas we would like to obtain a velocity such as this, we would escape entirely and go on out into space and never come back.

Actually, even if we do provide the correct velocity, we still have a problem. The figures I have drawn here(assuming that there are only two bodies in the universe, the earth and the vehicle) but the moon is out here somewhere, and it distorts the gravitational field to the moon when you distort this path. As this vehicle is traveling some elliptical path to strike the moon, actually instead of continuing to slow down and reach its lowest velocity here, it will start to speed up because it will begin to fall toward the moon and the moon will start tracking it.

We will assume we are not so accurate that we are going to hit the moon. I will not make such an optimistic guess as that, but if the vehicle comes real close to the moon as it goes by, it would speed up to a velocity of about 5,400 miles per hour; that is, it had 23,000 here, but it is slowing down and reaches a very low velocity here, but then it does speed back up to this number, and if it were to hit the moon, it would hit the moon at that velocity.

QUESTION: What is this velocity that it slows down to?

MR. SANDERS: I am sorry. I cannot tell you what it is. It is somewhat lower than that.

QUESTION: I had an astronomer figureout for me and he said it would be in the order of half a mile a second as it moved into the lunar gravitational field.

MR. SANDERS: Yes, and this corresponds to one and a half miles per second. If this vehicle comes close to the moon and goes on it will not stay in the vicinity of the moon because it would simply be deflected and then after it reached this maximum velocity and, going away from the moon, starts slowing down, it would never come back to the moon; it would go on over and continue around some path around the earth.

To make it stay in an orbit around the moon we have to have a retrorocket to slow it down and bring it down to a velocity necessary to make it stay in orbit around the moon. It depends on how close to the moon you are. It might be some velocity on the order of, in one case we calculated, 3900 miles per hour, but it depends on the orbit that might be chosen. These numbers in no way apply to anything that is imminent. These are just general calculations we have made.

QUESTION: You say that what you are attempting to do, then, is to slow this rocket down to a speed approximating 3900 miles an hour?

MR. SANDERS: In the particular case I have chosen. In principle, if you slow it down to a velocity less than this, it will follow through some elongated ellipse and if I wanted to put it down real close to the moon this is the number that I would have.

QUESTION: What do you mean by a "real close orbit"?

MR. SANDERS: This is a calculated figure in about one moon's radius; but don't relate this in any way to anything that is going to happen. These are just calculations we have made just to give you some idea of the magnitudes involved.

QUESTION: The moon radius is what?

MR. SANDERS: Isn't the diameter of the moon about 1000 or 2000 miles? In other words, the moon's radius is about 1000 miles.

Now, let's go back to the case where we have given it accidentally too much velocity and it not only goes by the moon and misses the moon, but also so much velocity that it will not stay in orbit around the earth. It goes on off and never comes back.

I said that, but that is not quite a correct statement. Again, we have neglected something, and that is this big old sun sitting over here which is exerting a tremendous influence on the orbit of these things.

What happens is this thing falls into an orbit around the sun. The velocity of the earth in orbit around the sun is around 66,000 miles per hour, and the velocity after the vehicle gets far away from here relative to the earth was of the order of a couple of thousand miles per hour, a very low number, so essentially it is traveling right around the sun at the speed of the earth or close to it.

Many, many years afterwards, presumably both the earth and this vehicle chasing the sun -- they might come together, but it will be years off -- so essentially we can say this vehicle is off if it gets to a greater velocity than this.

If we wish to go out in space to go close to Venus or go close to Mars, we are still dealing with a velocity of this order of magnitude, this escape velocity from the earth itself -- 25,000 miles per hour. But now we have to take into consideration the velocity of the earth and the velocity of the planets we are dealing with.

I will now draw the sun in a small block here. Here is the orbit of the planet Venus, orbit of the earth, orbit of Mars. Let's say the earth is moving in this direction, and at this point we wish to initiate a flight that goes to Venus.

If we shot it away from the earth at 25,000 miles per hour, when it got a little distance from the earth and it slowed down to orbital velocity it would follow it around so we have to slow it down. Actually we would do a firing in the opposite direction, but for the sake of simplicity we have to slow it down and put it into an ellipse like this.

If we left it with the velocity it would have after it escaped from the earth, when fired at that velocity it would follow around with the earth. By slowing it down, it would go into an ellipse and if we pick the correct velocity it will comd around and intersect the orbit of the planet Venus.

If we want to go to Mars, we must do the opposite; we must speed it up and make it go into an ellipse which comes around and comes close to the planet Mars. If we wanted this vehicle to stay in the vicinity of Venus when it got there, actually on this path it is going faster than Venus and it would go right by, so again, we would have to put on a retrorocket.

In the case of Mars, it is the other way around. We have to speed it up when it gets to the planet Mars. There is one other point I would like to discuss very briefly.

We know the laws by which these things move through space and we can predict it very accurately. If we had two boosters or rockets sitting on the ground, firing identical loads, giving the same velocity at the same point away from the earth, they would then -- we could calculate -- we would know they would follow absolutely parallel paths.

Now, suppose I was one of those objects and my lunch bucket were the other object. We would be flying through space and I would look out and see this lunch bucket right beside me. A little while later it would still be beside me. I would put my shoe out there and it would follow me around, too.

If I wanted to be gruesome about it, I hack off half my arm and it would go right along with me. It had been given the same velocity and same position I had been given. Now, that means even though my arm was attached to me here, there would be no force existing on that arm to move it relative to me; it would not be moved up or down or to the sides. In other words, I would not feel the weight of that arm at all nor would I feel the weight of any other part of my body. Therefore, I would feel that I was in a weightless situation.

But again, there is a misconception here. We are not free of gravity, because gravity is a thing that makes us travel in these elliptical paths. If there were no gravity, we would follow a straight path, so we are still subject to the laws of gravity.

The thing is, they are acting in the same way on all parts of me and I have the sense of weightlessness and that would be the situation of a man who was traveling in one of these unpowered orbits.

This concludes my discussion.

Q Doctor, when a rocket leaves the earth and you take advantage of the rotational speed of the earth, which is what?

A It is about a thousand miles per hour at the Equator.

Q Does that mean that that thousand miles an hour is added to the inherent speed of the rocket itself?

A If we take an Equatorial launch and launch it, we are taking advantage of it in the firings that have been done so far. So if we require a velocity of 18,000 miles per hour, actually the rocket system would only have to provide 17,000. However, let us suppose we wanted to put it into a Polar orbit, fire it so it can go over the Poles, we cannot add this velocity, so it is just in this special case, and we try to take advantage of this velocity, but in many missions we will not be able to do this. Some mission will call for something different, and we will not be able to take care of that.

Q When you fire from Cape Canaveral in a northeasterly direction, how much added speed are you getting?

A If you fire directly east at Cape Canaveral I think it is around 900 miles per hour.

Q You never do. You fire either southeast or northwest. I was asking if you fired into the northeast, like the Explorer Four.

A About 800 miles an hour, I am just told.

Q You have a figure of 23,900 miles per hour. Is that the desired velocity for this Trajectory you are talking about?

A   Yes, that is a velocity which will have an ellipse that will become tangent to the moon.

Q   At what altitude is that attained?

A   That is an equivalent velocity that must be given at the earth's surface to this.

Q   From the standpoint of actually firing a projectile in the direction of the moon, what burnout velocity would it attain?

A   I don't know. Usually there is a burning period of about five minutes, and the load has to be adjusted and it depends on the accelerations that you give. If you have an acceleration of 1.3 times gravity this might go to a couple of hundred miles at which time it burns out. I cannot quote you right now on the velocity of this.

Q   How close does this 23,900 have to be? How much variation can you have to limit yourself to a successful orbital moon?

A   I cannot tell you exactly. I will point out one point. When you pick this minimum energy situation that I have described in which the ellipse it is traveling on is tangent to the orbit of the thing you are coming to it is fairly insensitive to the errors there. But you frequently like to use more than this minimum energy type of operation from other considerations. Sometimes you would like to give the thing a little extra push and have this ellipse do things like this and pick up points like this. That is particularly true in the case of going to Venus or Mars. We would like to shorten the time it takes to get there. It takes quite long on this minimum energy ellipse. As far as the accuracy that is required is concerned, it is quite stringent actually and the chances of getting to the moon are pretty low.

Q Can you give me an estimate. Suppose you picked out what you wanted to do, and you decide that you want to sort of hit a tangent-type thing when you reach the moon, what kind of accuracy must that be in miles per hour, roughly speaking? Is it in the neighborhood of twenty or fifty, or several hundred, or what? How close would it have to be?

A It is much closer than twenty.

Q Would you say it was within five miles per hour?

A You are pinning me pretty close here.

Q Just a rough estimate.

A Yes, that would be about right.

Q You had to be within five miles per hour to do what?

A Don't go away quoting me that five miles per is the number here.

Q In other words, when you pick the orbit that you are trying to hit, be it a tangent or one that goes out and comes back, there are probably a limitless number of those, and then decide on what your speed must be, roughly speaking how close do you have to hit it?

A I would like to make a comment here. I think in the way you posed your last question, you presented a problem correctly. If you are trying to hit a specific point on the moon or a specific orbit around the moon, when the requirements are extremely stringent, and an amount, as indicated, before doing better than a few miles per hour. Also, your aiming has to be good. But this is not the way you do something of this sort, certainly not on the first go-round. As you indicated, there are infinitely many orbits around the moon that one could shoot for, and this relaxes somewhat the requirements on you. As long as we get into an orbit about the moon, that is sufficiently close, we are in. So this relaxes the aiming for us, but as far as getting close enough to the moon is concerned, we are still within this few miles per hour requirement.

Q Could you discuss the question of problems to Mars and Venus in terms of launching times. We are more familiar with the three days per month Lunar problem. How does that work out with Venus and Mars?

A That is a much less frequent occurrence. Because of the energy requirements we do have to stick fairly close to this situation which I have illustrated here -- when the earth is in this position it is launched here, so it will meet

Venus when Venus is at this point. That occurs once, I think, about 225 days, as I recall. The period of the earth is 365. I think it winds up that this thing occurs about once every eighteen months that you get this combination of positions at the right time so that you can fire a minimum energy type of thing.

Q How about Mars on that same point?

A It is a much longer period of time there. Now, we want to fire it from the earth, and then when Mars is at 180 degrees, the vehicle will arrive at the same time. There are some other things that enter into this thing, too.

Q What is the period on Mars?

A I think that is 687 days.

Q That is Mars, period.

A That is what the question was.

Q What is the interval for a good shot?

A I don't have that in mind, but it would be longer than the 687.

Q It is around four to six years.

Q You don't have an estimated date when these two bodies will be in those positions, do you? They are going to be there regardless of whether we do anything or not.

A Yes, the astronomers know this quite accurately.

Q Can you suggest an approximate date?

A Those events will occur this year sometime as far as Venus is concerned, latter part of 1960. As far as Mars is concerned -- correction, Mars is 1960. There are two dates. It takes 151 days for this to occur, so if Venus is in position here at the end of the year, this means somewhere along in the middle of the year it must be launched.

Q In the middle of what year?

A 1959.

Q That is for Mars?

A That is Venus.

Q What was that trip you wrote for Venus?

A 151 days. That is the minimum energy time.

Q This must come down to a very precise date that you have to send it up to reach the vicinity of Venus. Could you tell us what that date is?

A No, I can't. I don't know exactly.

Q Is this date in the last half of 1959 the date at which they are 180 degrees apart or the date on which you have to do your launching?

A The date that we would have to do our launching would be in the middle of the year. At that time Venus would be right here someplace, actually, and then in the time it takes the vehicle to move along this path, Venus will arrive here at the same time the vehicle does.

Q That would be down around seven o'clock?

A Yes, the earth would be in some position along here.

Q You would have to make your launching 151 days before Venus was down in that six o'clock position?

A That is precisely correct.

Q What about Mars?

A The same set of conditions hold true, and the flight time to Mars is around 250 days. I don't know that as exactly as I do this number.

Q It is 247.

Q So you would have to launch when and in what year for Mars?

A I don't know these dates. Somewhere in 1960 the earth will be in the correct position, such that 247 days later Mars will be in the correct position for it to strike.

Q It would have to be launched in 1960 to get there in 1961?

A That is correct.

Q What are these flight times based on in terms of velocity? It seems to me if you would accelerate you would be able to do it quicker.

A That is minimum energy. There you have an ellipse that just becomes tangent to the two orbits. As I stated you can generate an ellipse which goes across the other orbit and gives you a shorter flight time, and this is desirable certainly, but you are paying for it with energy and how far you are able to go is a technical question concerning the payload and what is available at the time.

Q To follow up this point, if you have a capability in terms of rocketry and guidance to go to the moon, how much greater a step is it to go on to Mars and Venus?

A From a propulsion standpoint, it is very great. The capability of the propulsion system to put it up is there, but it becomes a problem of guidance and communication.

When we talk about a very light weight vehicle carrying a radio transmitter and firing it fifteen million miles away, there is the question of getting the signal.

Q And there is ten to twenty minutes delay?

A That is right.

Q What is the time period during which on each of the days during your lunar probe launching you can still fire and hope to make it?

A I don't know. I think this would be a subject for discussions tonight. I don't know the answer to that.

Q It was eighteen minutes at Cape Canaveral.

Q Doesn't that go to this question of how you get there?

A May I put something in here. This depends upon the guidance system you have, the kind of course reckoning you can make and the kind of energy you have over and above the minimum energy required to do the paths. There are an infinite number of paths you could pick. If you restrict yourself to a fairly simple guidance system, fairly simple course corrections in flight, then this time interval is not very long. It will be on the order of ten to twenty minutes to get over in that period if you hope to accomplish a mission, defining a mission as merely getting into the vicinity of the moon.

If you go to the other extreme and had all the energy you could use and had very excellent guidance and so on, you could fire any time, because by definition you could fire and correct in flight. It depends upon the state of the art of propulsion and gadgets, and there is no precise answer except to say if you try to do it as simply as you can, you don't have very long. You have this ten to twenty minutes.

A If you had infinity power in your propulsion system, you could make it hit in a whole variety of positions here, but if you use the minimum energy, theoretically there is only one point. Then it is how much excess you have and so on that gives you freedom here.

A If you could go the speed of light, it would only take you one and a third seconds to get there. Let's take this as a limit. If you could possibly drive your vehicle that fast you could get there in about one second. If you got at minimum energy it would take 2.6 days.

A The fact that the launching site is not on the Equator gives rise to certain limitations on the time that this firing can occur, but this is not part of the discussion as we have made it.

Q Why is that?

A These vehicles travel in a plane. All of these orbits that we have here travel in a plane with the center of the earth. The moon moves around the earth in the ecliptic, and as long as you fire in a position within the ecliptic you are not limited -- this is not quite a correct statement -- you are not limited in the time you can fire, but once you get outside of this ecliptic, you have to wait for these times when the plane of the moon -- this is a little complicated -- I would have to use a three-dimensional cardboard model to explain this.

Q What do you mean the moon travels in an ecliptic? What do you mean by this expression?

A The plane of the orbit of the moon is approximately in a plane of an ecliptic. It is inclined to some degree.

Q Let's try that again, please.

A If I may add a few words here, the solar system is essentially spread out in one plane, not exactly. The sun, the various planets, including the earth, all revolve essentially in a single plane. Let's suppose this desk is a plane here. When we look up on to the sky the inner section of that plane with the sky is the ecliptic, and one of the ways in which we can know where that ecliptic is, is by watching the apparent motion of the sun throughout the year. It simply seems to go around us. Actually we are going around the sun.

The moon's orbit also lies in a plane about the earth. However, that plane is inclined to the plane of the solar system, so you see the moon is going around an orbit, say the plane of this blotter, and intersects the ecliptic at only two points. When we fire an object out into space from the earth, we are essentially firing this object out into a plane coinciding with that of the ecliptic, so we have the problem of putting this object into an orbit in the ecliptic and making it intersect another orbit that is in a different plane which means that the intersection problem is even worse than if the two orbits were both in the plane of the solar system.

Q What is the angle of the moon's plane in relation to the ecliptic?

A That is six degrees.

Q Does it go up and down six degrees?

A Yes.

Q A total of twelve?

A It could be a total of twelve from the plane of our Equator.

Q Why can't you shoot your rocket in the same ecliptic as the moon?

A In the plane of the moon?

Q Yes.

A In the case of the moon, this can be done, but in the case of firing out to Venus, now this is more difficult to do, and again brings in the difficulty in aiming.

Q Have you made any changes in the PIONEER vehicle or the instrumentation?

A That is an out-of-order question. Ask it tonight.

Q How can you fire to get into the moon's plane? It seems to me you are determined from where you are firing from and you are in a plane and can't get out of it.

A This is what Newell Sanders meant when he said this increases the difficulty. In order to fire into the plane in which the moon's orbit lies, you have to fire at a time when your launching site is in that plane, or you have to direct your vehicle from your launching site into that plane and then have your last stage sort of dog-leg your trajectory into that plane.

Q In order to get into the moon's plane, you have to be six degrees north or south of the Equator, do you not?

A It is six degrees north or south of the ecliptic, and the ecliptic is 23 degrees 27 minutes at that angle to the Equator.

Q Dr. Newell, the main probelm is slipping the moon payload into the plane of the Lunar orbit around the earth. The inclination of the plane of the Lunar orbit never climbs as high as Cape Canaveral.

A That is the probelm.

Q In other words, the maximum is 28 degrees, and the maximum at Cape Canaveral is 33?

A That's right. If we were firing from the Equator our choices of times to fire would be much relaxed.

Q I suppose as a corollary to that is the time factor on the Soviet Union which has a much more stringent factor?

A Yes, I would say so.

Q Mr. Newell, would it be worthwhile to try to get an Equatorial launching site? Would the difference in what you would have to pay for it warrant it?

A I would say for many reasons it would be worthwhile to have the flexibility of firing from the Equator or from a northern site.

Q Has anyone suggested this to the Government?

A We have been thinking about that for quite a while, yes.

Q Dr. Newell, when you say you would have more flexibility, what would that be on the order of, once a week, twice a week, any time you want it, or what would it be compared to what you now have?

A I am thinking of just more than lunar and space probes when I say flexibility. If you fire from a launching site that is north of the Equator, let's say Cape Canaveral, or any other place like that, or in the Soviet Union, then your orbit will have to be inclined to the Equator at least equal to the lattitude of your launching site. You can't get an Equatorial launching unless you go through the procedure of sending up your launching vehicle, having a stage in it which will dog-leg it down to the Equator, and turn it parallel to the Equator and then have your final stages firing parallel to the Equator. Your launching operations then become very difficult and are difficult to carry out. However, if you are on the Equator you can fire in any direction and get an Equatorial direction or a Polar angle, or any other orbit. Being on the Equator you are simply related to rotational motion of the earth, and you can pick firing times so that when your launching spot can be at the intersection of the ecliptic with the Equator at the time you want to fire so that you can project into the plane of the solar system if you want.

Simply, the orbit of the moon crosses the Equator in two places, and you can wait until your launching site comes around to the spot where at that moment the moon's orbit crosses and project your vehicle out into the plane of the moon. This is what I mean by flexibility.

Q Dr. Sanders, approximately how many millions of miles are represented in the elliptical paths that take 151 and 247 days?

A The closest approach there between Venus and Earth, I think the distance is around 24 million miles. That is the straight distance. I have to make a little calculation in my head to do this. The earth is 93 million miles from the sun, so we could say that probably you could represent that by a circle whose radius is, let us say, 93 minus a half -- let us make it about 80 million miles as the radius. Therefore, it is 80 million miles times pi, or 240 million miles.

Q Half of that to go from the Earth to Venus?

A I picked a radius there, so multiply the radius by pi, which is half already.

Q About 120 million or 240 million?

A 240 million, roughly, to Venus.

Q And about what for Mars?

A Yes, it is more for Mars. Mars comes within about 36 million miles to earth. It would be about 350 million miles. This is a rough calculation.

Q This is the diameter of the orbit?

A It is half-way around the complete ellipse.

Venus is inclined about 3 degrees. Mars is pretty close to the same plane.

Q Are plans afoot now to make launches or to try to make launches in the first half of 1959 and in 1960 for Venus and Mars respectively?

A I don't know what it is there.

Q To return to Canaveral, what is the optimum angle of launch? We read apropos the PIONEER that there was an error of 4 degrees or something in that order.

A Do you mean optimum angle to reach the moon? If that is what you are talking about, I don't know the answer to that.

Q The story was the vehicle encountered excessive gravitational pull which reduced its velocity by, I think, somewhere between 300 and 500 miles at the crucial stage.

A I think there were a combination of things that have not been sorted out. It was not just one item that caused that.

Q I am talking about a theoretical flight now. There must be an optimum angle that you could work out in celestial mechanics.

A Yes, and it is set by the inclination of the orbit.

Q Do you know whether we have hardware on the shelf that could be adapted in a year and a half to approach Venus and Mars?

A Yes, essentially the booster equipment is capable of it right now.

MR. BONNEY: Gentlemen, we have had a full hour of it. If you would be interested we can try to arrange one of these at a later time in the next two or three weeks and take another crack at trying to educate ourselves.

I want to thank these gentlemen, and then I might go completely off the record just to get into a couple of logistics for this evening.

(The Press Conference was concluded at 11:00 a.m.)